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 Lightning Labs, Inc.*

**UNITED STATES DISTRICT COURT
 FOR THE NORTHERN DISTRICT OF CALIFORNIA
 SAN FRANCISCO DIVISION**

TARI LABS, LLC, <div style="text-align: center;">Plaintiff,</div> <div style="text-align: center;">-against-</div> LIGHTNING LABS, INC. <div style="text-align: center;">Defendant.</div>	X : : : : : : : : : : X	CASE NO.: 3:22-cv-07789-WHO DECLARATION OF JP SINGH IN OPPOSITION TO PLAINTIFF’S MOTION FOR A TEMPORARY RESTRAINING ORDER
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2 I, Jaswinder (“JP”) Singh, hereby declare:

3 1. I am a resident of the State of New York and I am over the age of eighteen. I
4 submit this declaration based on my extensive academic experience and personal knowledge
5 in connection with computing systems and applications, including software development and
6 design in general and in the blockchain and cryptocurrency space in particular.

7 2. I have been asked by counsel for Defendant Lightning Labs Inc. (“Lightning
8 Labs”) to explain (1) how Bitcoin and open-source software development works; (2) the
9 nature of the Bitcoin software developer community; (3) the meaning of the terms
10 “developer-facing” and “consumer-facing” as they are used in the software development
11 community; and (4) Lightning Labs’ proposed TARO protocol for the Bitcoin blockchain.
12 My opinions on each of those topics is set forth below.

13 3. I am being compensated at a rate of \$1,400 per hour for my work in preparing this
14 declaration.

15
16 **My Background and Professional Experience**

17 4. I am currently a Professor of Computer Science at Princeton University, a
18 position I have held for more than 15 years. I hold an endowed professorship as the inaugural
19 Professor of Computer Science, Technology, and Societal Change at Princeton University.
20 Before becoming a Full Professor, I was an Assistant, and then Associate, Professor at
21 Princeton. I became an Assistant Professor at Princeton in 1995. My current curriculum
22 vitae (“CV”) is attached to this declaration as Exhibit A.

23 5. In December 2022, I testified as an expert by deposition in *Advanced Cluster*
24 *Systems, Inc. v. NVIDIA Corp.*, No. 19 CV 2032 (D. Del.), on behalf of the Plaintiff.

25 6. I received a Bachelor’s Degree in Electrical Engineering and Computer Science,
26 summa cum laude, from Princeton in 1987. I received an M.S. Degree in Electrical
27 Engineering in 1989 and a Ph.D. Degree in Electrical Engineering in 1993, both from
28 Stanford University. For my Ph.D. thesis, I researched the boundary of applications and

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2 parallel computer systems. In 1997, I was honored with a Presidential Early Career Award
3 for Scientists and Engineers (PECASE), which is awarded to about twenty young scientists
4 and engineers in the United States selected from all areas of science/engineering by the
5 National Science Foundation, and in 1998 with the Sloan Research Fellowship, awarded to
6 about ten Computer Scientists nationwide by the Alfred Sloan Foundation. I am a member
7 of the Association for Computing Machinery and the Institute of Electrical and Electronics
8 Engineers.

9 7. I am the inaugural Professor of Computer Science, Technology, and Societal
10 Change at Princeton University in the Department of Computer Science. I joined Princeton
11 in 1995 as an assistant professor. I became a tenured associate professor in 1999 and full
12 professor at Princeton in 2005, and I was named to my current endowed professorship in
13 2022. In general, my academic research focuses on large-scale computing systems and
14 applications, and the implications of such applications for software and architectural design.
15 Among other works, I am the author of *Parallel Computer Architecture: A*
16 *Hardware/Software Approach*, a primary textbook in the parallel computing field. For the
17 past two years, I have taught a class at Princeton focused on blockchain technology called
18 “Web3 – Blockchains, Cryptocurrencies, and Decentralization.”

19 8. Since 2010, I have taught a new class at Princeton called “Innovating at the
20 Boundary of Technology and Business,” which aims to trains students toward becoming
21 highly effective chief technology officers (“CTOs”).

22 9. I am currently the founding co-director of the Princeton Center for the
23 Decentralization of Power Through Blockchain Technology, also called the “DeCenter,” a
24 university-wide interdisciplinary center originating in the School of Engineering and Applied
25 Science. The DeCenter focuses on technology, applications, and policy and social
26 implications of blockchains.

27 10. From 1999 to 2010 I was the director of Princeton’s “Program in Integrative
28 Computer and Application Sciences” (PICASs), a multi-department, university-wide

interdisciplinary program focused on scalable parallel and distributed computing at the boundary of computer science and a broad range of application areas.

11. I am the author of a leading textbook on parallel computing, “Parallel Computer Architecture: A Hardware-Software Approach,” by David E. Culler, Jaswinder Pal Singh with Anoop Gupta, Morgan Kaufmann Publishers, 1999. I have also published more than 100 referenced conference and journal publications.

12. I am co-founder of a startup called Trust Machines, that builds on the Bitcoin blockchain, to build a large ecosystem of novel applications and needed technologies that take advantage of the most important properties of the Bitcoin blockchain.

Background on Bitcoin and Open-Source Protocols

13. Bitcoin is the oldest and most well-known of the modern public, cryptographically secured blockchains. In simple terms, a blockchain is a ledger that records information. Each piece of information in the ledger is stored in a unit called a “block” and, over time, those blocks are linked together, forming a “chain” of information. Unlike traditional databases, whose maintenance and accuracy are typically entrusted to a centralized entity, or perhaps a federation of entities, blockchains like Bitcoin are designed to be public and decentralized. No single entity (or fixed set of entities) maintains the blockchain, and no single entity must be trusted to maintain the authoritative ledger.

14. The Bitcoin blockchain was first proposed in 2008 in a white paper by the pseudonymous Satoshi Nakamoto. That white paper, called *Bitcoin: A Peer-to-Peer Electronic Cash System*, launched the modern blockchain industry by proposing a way to cryptographically secure information and maintain agreement about it in a public, decentralized ledger without centralized authorities. This solved a major problem in achieving trust among an unknown set of system participants without any centralized intermediary or authority. The invention of Bitcoin is considered one of the most significant technical innovations of the past several decades.

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2 15. In 2009, the software for the Bitcoin blockchain was released by Satoshi
3 Nakamoto as “Bitcoin Qt.” That software, now known as Bitcoin Core, is open source and
4 available on Github (a commonly used code repository) at www.github.com/bitcoin/bitcoin.

5 16. Bitcoin has an active developer community and a healthy ecosystem, of which I
6 am a member. The Bitcoin ecosystem contains, among others, developers who work on the
7 Bitcoin blockchain itself (referred to as the “layer one” Bitcoin blockchain) as well as
8 developers who work on additional layers of technology on top of the Bitcoin blockchain
9 (which rely on Bitcoin’s stability and other core properties but add new features and
10 capabilities) and developers who work on applications. All of these developers are members
11 of the Bitcoin developer community, which I discuss in the next section.

12 17. Bitcoin’s original design was solely intended to support a decentralized peer-to-
13 peer payment platform (as the title of the white paper referenced). Bitcoin’s layer one –
14 sometimes called “mainnet” or “mainchain” or the “base layer” – is the core of the Bitcoin
15 network and includes the distributed ledger of the Bitcoin blockchain itself. Integral to
16 Bitcoin’s proper functioning are nodes that maintain copies of the ledger and process
17 transactions, Bitcoin’s proof-of-work consensus mechanism, and miners who contribute the
18 “work” needed for the consensus mechanism.

19 18. Bitcoin’s layer one is remarkably simple and elegant from a technical
20 perspective—which is a great strength. It has demonstrated integrity and durability through
21 nearly 14 years of continuous operation with minimal disruptions and with minimal
22 modifications to the core protocol.

23 19. Blockchains that were developed after Bitcoin—like Ethereum—used the basic
24 concept of the blockchain that Satoshi Nakamoto pioneered and added additional features,
25 such as the ability to create general-purpose smart contracts, that do not exist in Bitcoin’s
26 layer one, and decentralized applications (“dApps”) that rely on these smart contracts.
27 Recognizing the value those additional features can bring to a blockchain ecosystem, many
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1
2 members of Bitcoin's community (including myself) are developing applications and
3 contributing to additional layers on Bitcoin.
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5 **The Bitcoin Developer Community**

6 20. Software developers who work on Bitcoin layer one or other Bitcoin layers must
7 understand Bitcoin's software or protocol to build their technologies. Although today there
8 are many blockchains out in the world, each blockchain has different software with different
9 features and different functionality.

10 21. In my experience, many developers who work on Bitcoin or on other Bitcoin
11 layers do so because they believe it is the best layer one blockchain protocol: it has proven
12 and tested decentralization, stability, and security. Many developers also recognize that
13 Bitcoin has tremendous potential beyond the peer-to-peer payments functionality (with
14 limited scalability) of Bitcoin layer one.

15 22. Like other software developers, Bitcoin developers are highly technical and
16 sophisticated individuals, who use programming languages as well as developer-focused
17 tools as an ordinary part of their jobs. Like other professionals, developers take great care in
18 selecting the tools that they use for their work. Developers also pay close attention to the
19 tools that they are using, because each tool has specific features and characteristics. For
20 example, a software developer will know exactly what programming language they are
21 working in. Software developers will also know exactly what protocols or application
22 programming interfaces ("APIs") they are using, because the resulting software being
23 developed will not function if they misuse these protocols or interfaces.

24 23. In my experience, the Bitcoin developer community is distinct from the
25 community of developers that works on other blockchains, which also have their own
26 distinct developer communities. For example, Ethereum is another widely known and used
27 blockchain. To my knowledge, very few developers actively work on software for both the
28 Bitcoin and Ethereum blockchains. The underlying code base is different, and the protocols

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2 and functionality of the blockchains are different. To the best of my knowledge, as a general
3 matter, an active Bitcoin developer is not likely to work on projects for other blockchains, or
4 use developer-facing tools designed for other blockchains, because those are not relevant to
5 their work. In my experience, Bitcoin developers are well aware of what developer-facing
6 tools are useable on the Bitcoin blockchain, and, with the exception of some very prominent
7 and widely used tools on one or two other blockchains (which Bitcoin developers would be
8 aware are not able to be used with the Bitcoin blockchain), they generally they pay little (if
9 any) attention to those that are not.

10 24. Reputationally, developers are attracted to different blockchain protocols for a
11 variety of reasons, many of which are specific to those protocols. In particular, many
12 Bitcoin developers believe that Bitcoin is the best blockchain because it has proven
13 properties including durability and utility. Bitcoin solved a real-world problem by enabling
14 peer-to-peer electronic payments without a centralized intermediary, and the bitcoin
15 cryptocurrency today has significant real-world value for consumers or businesses who want
16 to store and transfer value over the internet in a decentralized manner.

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18 **Developer-Facing Software Versus Consumer-Facing Software**

19 25. Within the software development community, it is widely understood that some
20 software is developer-facing and other software is consumer-facing, and developers use
21 those (or similar) terms to distinguish between different types of software. Developer-facing
22 software refers to tools, protocol implementations, or platforms that other developers use to
23 build their own software. Consumer-facing software refers to applications or “end products”
24 that are targeted to consumers who want to use the application without needing to know how
25 it is built or what tools, protocols, or platforms the developers used to build it.

26 26. To illustrate the difference between developer-facing tools or protocols, and
27 consumer-facing end products, we can consider the example of email. Ordinary consumers
28 send and receive email using consumer-facing applications like Gmail, Yahoo Mail, or

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2 Hotmail. Those applications make sending and receiving email easy: you press a button and
3 your email is sent or new email appears. The developers who created the core functionality
4 of applications like Gmail – how the application interacts with underlying Internet related
5 protocols to enable the sending or receiving of email – would need to be intimately familiar
6 with the developer-facing protocols that are used by, or to build, the consumer-facing
7 software that allows people to send emails. For example, the Simple Mail Transfer Protocol
8 (SMTP) governs how a mail message is sent from a mail client to a mail server. The Internet
9 Message Access Protocol (IMAP) governs how mail messages are retrieved by a mail client
10 from a mail server. Underlying SMTP and IMAP is the Transmission Control Protocol, and
11 underlying it is the Internet Protocol (together called TCP/IP) that is the foundational
12 framework for the internet itself. So, when a user checks their Gmail inbox or sends an
13 email, they are using a consumer-facing application that uses SMTP, IMAP, and TCP/IP to
14 function, but ordinary consumers need never be aware of any of those protocols. They just
15 know their Gmail works.

16 27. I am also familiar with the defendant in this case, Lightning Labs. The Lightning
17 Network protocol (sometimes called Lightning or LN) is a “layer two” payment protocol on
18 Bitcoin for fast and inexpensive payments. Lightning Labs builds developer-facing tools for
19 the Lightning Network. I had heard of Lightning Labs and its co-founder, Elizabeth Stark,
20 very positively for some years. When colleagues and I were organizing the Princeton
21 DeCenter’s inaugural summit (held in November 2022 at Princeton University), I proposed
22 inviting Elizabeth to speak at the summit. She was our lunchtime fireside-chat speaker,
23 interviewed about topics concerning Bitcoin, its protocols and history, and the Lightning
24 Network.

25 28. Because the Lightning Network is intended to solve a real-world problem for
26 consumers, by making cryptocurrency payments cheaper and faster, the Lightning brand
27 itself is used by consumer-facing applications, like wallets (which store digital assets).
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29. Lightning Labs builds developer-focused products that can be used to build those consumer-facing applications. For example, Lightning Labs has products called Pool, Loop, Lightning Network Daemon, and Neutrino. *See* <https://lightning.engineering/products>. These products are intended to be used by developers and other sophisticated users of the Lightning Network, not ordinary consumers. Ordinary consumers may use their Lightning wallet to send digital assets to a friend, and that transaction may be facilitated by the Lightning Network Daemon or Neutrino, but ordinary consumers would not be aware of those developer-facing products.

Bitcoin's Taproot Update and the TARO Protocol

30. In November 2021, the Bitcoin protocol was updated to include a new set of features that are called Taproot. Taproot is intended to make Bitcoin transactions more efficient and increase their privacy. Taproot can significantly expand the types of transactions that are possible on Bitcoin.

31. In April 2022, Lightning Labs announced development of the TARO protocol. TARO stands for Taproot Asset Representation Overlay. Because I actively follow developments in the Bitcoin space, I learned about TARO very soon after it was announced. The TARO protocol, which is currently still in testing and does not exist on Bitcoin's mainnet, leverages the Taproot update to allow developers to structure Bitcoin transactions in new ways and issue new assets that can be transacted on the Bitcoin blockchain, either on Bitcoin layer one or using the Lightning Network layer. The company I co-founded, Trust Machines, has also published an article on the TARO project that is intended to help our audience for such articles (comprised mostly of technical Bitcoin developers) understand TARO. Trust Machines, *What is Taro and Bitcoin Multi-Asset Issuance?*, <https://trustmachines.co/learn/bitcoin-taro-protocol/>. Trust Machines has also published similar developer-focused articles (like "An Introduction to Building on Bitcoin" and "What are Bitcoin Discreet Log Contracts (DLCs)?").

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2 32. TARO is not itself a blockchain or a digital asset. TARO can be used to issue
3 new digital assets that can be transferred on the Bitcoin blockchain, either on Bitcoin layer
4 one or using the Lightning Network layer. Digital assets that are created with TARO can be
5 held in ordinary Bitcoin or Lightning Network wallets.

6 33. The initial open-source alpha release of TARO occurred on September 28, 2022,
7 when Lightning Labs published the TARO code repository on a public Github.

8 34. It is my understanding that within the Bitcoin developer community, the TARO
9 proposal was widely recognized as a potentially important tool that Bitcoin developers will
10 be able to use to create new digital assets or other products on the Bitcoin blockchain. While
11 ordinary consumers who hold Bitcoin or use Bitcoin to make peer-to-peer payments are
12 unlikely to ever see the TARO name, it is my understanding that many Bitcoin developers
13 have paid close attention to the features and functionality of the TARO protocol, and
14 developers are contributing to the TARO code and experimenting with the alpha TARO
15 software on Bitcoin's test network.

16
17 **Conclusions**

18 35. For the reasons set forth above, in my opinion, software developers are a highly
19 technically sophisticated group of professionals. Software developers, and those in the
20 software development industry, commonly understand the difference between developer-
21 facing and consumer-facing software. When choosing developer-facing software,
22 developers pay careful attention to what they are using. In the blockchain space, there are
23 distinct communities of developers around different blockchain projects. The Bitcoin
24 developer community focuses on Bitcoin and developer-facing software that functions on or
25 utilizes the Bitcoin blockchain. To the best of my knowledge, the Bitcoin developer
26 community in particular pays careful attention to the developer-facing software they use to
27 create software or applications for the Bitcoin blockchain, and, with few exceptions,
28 generally they pay little (if any) attention to software or applications that are developed for

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2 other blockchains. It is my understanding that many Bitcoin developers have paid close
3 attention to the Bitcoin Taproot update and the proposed TARO protocol as they develop
4 other software or products for use on the Bitcoin blockchain, as these are developer-facing
5 protocols with associated software for the Bitcoin blockchain.
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7 I declare under penalty of perjury under the laws of the United States of America that the
8 foregoing is true and correct.

9 Executed this 27th day of February 2023, in New York, New York.

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12 JP Singh
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